Technical Bulletin

Flame Retardants: Balancing Benefits and Risks

Residential building fires fire continue to be a major cause of injury and death in the United States. From 2008 to 2017, there has been a 2% increase in fires and an 8% increase in deaths, with dollar losses exceeding 7 billion dollars. Specifically, in 2017, there were 372,500 fires, 2,695 deaths, and 10,825 injuries, with the majority of fires resulting from cooking and heating processes. Upholstered furniture remains one of the first items ignited in a residential fire and serves as fuel for the fire spread. Many deaths from fire occur from inhaling smoke or toxic gases, not from burns directly. Young children and older adults are among those at most risk. (Ahrens 2011, CDC 2012, Karter 2011, FEMA 2019).

Chemicals used as flame retardants to manage fire have been used for years. However, recent knowledge of health risks associated with certain flame retardants has sparked a debate about whether the benefits outweigh the risks. This debate has gained significant public exposure as public health agencies have outlined the concern of certain flame retardants as environmental and human health hazards. An overview and health issues were first highlighted in series of articles in the *Chicago Tribune*.

Flame retardants have been in use since the 1940s, starting with polychlorinated biphenols (PCBs), which were ultimately banned in 1979 as a human health risk. They were replaced by polybrominated biphenols (PBBs). These, too, were phased out as researchers determined they are structurally very similar to PCBs and as a result might also pose a risk to health. (Babrauskas et al 2011, Blum et al 2010, Lorber and Cleverly 2010, WHO 2004).

Brominated and chlorinated flame retardant chemicals, which were introduced in the 1970s and 1980s to replace PBBs, were found to be the most cost-effective ways for products in general and to meet the California Furniture Flammability Standard TB117, a “defacto” national standard for upholstered furniture. But, like their predecessors, brominated fire retardants (BFRs), polybrominated diphenyl ethers (PBDEs), and chlorinated fire retardants have been implicated as threats to health. (Babrauskas et al 2011, Blum et al 2010, Lorber and Cleverly 2010, WHO 2004).

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Polybrominated diphenyl ethers are a class of BFRs and are one of five “families” of flame retardants, including brominated, chlorinated, phosphorous-containing, nitrogen-containing (melamine), and inorganic (antimony, aluminum and tin compounds). Considered among the most effective flame retardants for preventing a fire from starting, BFRs inhibit the chemical reaction that takes place during gas-phase combustion, thereby slowing or blocking a fire’s ignition. Fire retardants containing chlorine are also very effective. However, when compared with BFRs, higher quantities of chlorinated flame retardants are often needed to achieve the same effect. As a result, BFRs were often selected when both performance and cost are considered (Blum et al 2010).

Polybrominated diphenyl ethers are commonly used in textiles for upholstery, carpet, bedding and draperies; flexible polyurethane foams used in upholstery furniture and car seats; electronic and electrical components; and plastics used in the casings of televisions, personal computers, and other electronic equipment.

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Depending on the chemical structure, there are 209 possible PBDE compounds. Polybrominated diphenyls have been marketed in three primary formulations.

Pentabromodiphenyl ether (penta-BDE), Octabromodiphenyl ether (octa-BDE), Decabromodiphenyl ether (deca-BDE) are classified as persistent organic pollutants (POPs), as they have been found to accumulate in humans, wildlife and plant life worldwide. In a comprehensive assessment of PBDEs, the US Environmental Protection Agency (US EPA) concluded that the key routes of human exposure are likely from their use in household consumer products and their presence in house dust, not from dietary routes, as with other POPs. The assessment also reported that breast-fed infants have the highest intake dose based on body weight, while children have a higher intake based on body weight than adults. (Lorber and Cleverly 2010, Hegstad 2010a).

Polybrominated diphenyls are structurally similar to PBBs, PCBs, dioxins and furans, which are known to be toxic to humans. Results of studies suggest potential concerns about liver toxicity, thyroid toxicity, developmental and reproductive toxicity, and developmental neurotoxicity from exposure to PDBEs. These studies' findings raise particular concerns about the potential risks to children. The carcinogenic potential of some PBDEs also have been studied. (Lorber and Cleverly 2010, Hegstad 2010a, Blum et al 2010, US EPA 2006).

As a result, there has been increased market and legislative pressure to find alternatives to PBDEs. In 2003, the European Union, for example, banned two of the three most commonly used PBDEs (Octa-BDE and Penta-BDE). In 2004, California became the first US state to ban Octa-BDE and Penta-BDE. The US EPA supported a voluntary program to phase out use of Deca-BDE by the end of 2013. In 2009, Manufacturers and the US EPA also reached a voluntary agreement to phase out production of Deca-BDE. Further, in 2009, the US EPA announced that it would use its authority under the Toxic Substances Control Act (TSCA) to require that new uses of PBDEs be approved by the agency and to add PBDEs to the TSCA 5(b)(4) risk list .(Babrauskas et al 2011, Hegstad 2010a.)

A commonly used chlorinated flame retardant includes Tris (1, 3 dichloro-2-propyl) phosphate or TDCPP, a widely used replacement flame retardant for Penta-BDE in polyurethane foam. Known as chlorinated Tris, the chemical was removed form children's pajamas in the 1970s, but continued to be used in home furnishings, including couches, chairs, pillows and ottomans; automotive applications, such as seat padding, overhead liners, foams and infant car seats; and bedding. Results of studies showed TDCPP, like Penta-BDE, can migrate from foam products into the indoor air and settled dust. These

semi-volatile compounds also can form thin films on walls and windows. As noted, the inhalation and ingestion of contaminated dust has been shown to be a major route of human exposure, especially for children. (Babrauskas et al 2011).

Chlorinated tris has subsequently been found to be a probable human carcinogen in a US Consumer Product Safety Commission (CPSC) study. The CPSC report estimates the lifetime cancer risk from tris-treated furniture foam is up to 300 cancer cases per million. The CPSC chronic hazard guidelines define a substance as hazardous if lifetime cancer risk exceeds one in one million. The US EPA considers TDCPP a moderate hazard for cancer and reproductive and developmental effects (Babrauskas et al 2011). In October 2011, California's Office of Environment Health Hazard Assessment (OEHHA) listed TDCPP on its Proposition 65 list of chemicals. The OEHHA has proposed a No Significant Risk Level (NSRL) for TDCPP of 5.4 micrograms per day. Any product offering an exposure greater than this level must be appropriately labeled as a cancer risk.

As replacement for organohalogen flame retardants a range of non-halogenated organophosphate ester flame retardants (OPFRs) have become commonly used. These include TEP (triethyl phosphate), TCEP (tris 2-chloroethyl phosphate), and TPHP (triphenyl phosphate), among others. Data is indicating that OPFRs show accumulation in the environment and present human exposure potentials. The human risk of OPFR exposure is not yet well established, but their presence in environmental samples and use in numerous consumer products warrants further study and use management. (Blum et al, 2019).

In 2014, Chemical Insights began a journey of bringing stakeholders together to understand the issues surrounding OPFRs and their use in upholstered furniture, one of the most common consumer products in a residential environment. This led to a major research initiative to develop exposure methodologies for 1.) studying the release processes of an OPFR into the environment from a furniture product containing the flame retardant and 2.) evaluating flammability performance of furniture manufactured with and without flame retardants. The objectives of the study were to develop knowledge on how we might achieve fire safe and chemical safe products for consumers and minimize the risks of both hazards. For detailed information, this report is available. (Black et al., 2019).

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